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United States Department of Agriculture,

BUREAU OF SOILS—CIRCULAR No. 13. Revised.

MILTON WHITNEY, *Chief of Bureau.*

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., April 8, 1905.

SIR: I have the honor to transmit herewith a manuscript, "The Work of the Bureau of Soils." This is intended for distribution at the Lewis and Clark Exposition at Portland, Oreg., and contains a condensed account of the work of this Bureau, with particular attention to its practical side. I respectfully recommend that this be published as a revised edition of Circular No. 13 of this Bureau.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

THE WORK OF THE BUREAU OF SOILS.

In 1894 a division was created in the Weather Bureau "for the study of climatology in its relation to soils." At the time of its creation it had a chief of division, 4 soil experts, 3 clerks, and 2 laborers. On July 1, 1901, the Division was made an independent bureau of the Department of Agriculture, and on January 1, 1905, its force consisted of a chief of bureau, chief clerk, 83 scientists and soil experts, 13 tobacco experts, and 29 clerks and other employees. Thus, in ten years its personnel has increased from 10 to 127, or more than 12 times. Great as this increase has been, however, the Bureau's force is not adequate to meet half the demands made on it for investigations along its special lines.

It was not a new problem which the Bureau undertook to solve. The study of soils had been carried on by State organizations and foreign governments for nearly a century. Many attempts had been made to classify soils according to the laboratory results obtained in investigations of the chemical composition or the physical properties of the soil, but the problem proved too intricate for solution by

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laboratory methods alone. Many soil maps had been prepared, but they were based upon the geology of the area and were of little or no use to the farmer. At the time the new Division began its work the futility of former methods of soil classification was beginning to be realized.

THE SOIL SURVEY.

The original object in the organization of the Division of Soils was to study the relation of the climatic conditions of moisture and temperature under the surface of the ground to the local distribution of crops. This work was largely of a technical nature, and involved questions of soil conditions and plant growth with which soil investigators all over the world had long wrestled. While the Bureau of Soils is now, and has been from the first, working on these intricate problems, it promptly undertook work of more immediate benefit to the farmer. It saw that differences in the commercial value of land could be detected in the field from the character of the soil and its relation to crops. It believed that if a classification of soils with reference to texture and structure, physiographic position, and crop values were made and the areas of different soils outlined in colors on maps, this would enable a farmer or a prospective purchaser of land in the area to determine at a glance the quality and farming value of any tract of land. Moreover, by carrying into a new area the knowledge of soils and crops gained in former surveys, it could enable the farmers of the new area to profit by the experience of those in the areas previously surveyed. This has proved especially valuable in the case of special industries, such as the production of tobacco, fruit, truck, sugar beets, etc.

So prompt were the farmers to recognize the value of this survey work, and so great was the demand for surveys all over the country, that the Bureau was compelled, contrary to its previous plans and almost against its will, to abandon certain lines of more technical investigation and devote a large part of its energy to the soil survey work. This work is now being carried on by 20 field parties working in as many States and Territories. A soil party consists generally of two men, who are equipped with a compass, an odometer for measuring distances, sometimes with a plane table to make or correct a base map, and with a soil auger to take samples usually to a depth of 3 feet in humid regions and 6 feet in arid regions, but by means of extensions capable of taking borings to a depth of 18 feet. Parties in arid regions where alkali is likely to be encountered are equipped with a portable outfit of instruments and chemicals for determining in the field the total salt content of the soil, and the chemical composition of the alkali salts and irrigation waters. Selecting some town in the area to be surveyed for its temporary headquarters, the party

hires a horse and buggy and carries on its work about as follows: Driving along a road, one or both of the men go out into the fields for a distance of half a mile, more or less, according to the character of the country and the position of other roads, and take frequent borings. They examine the material carefully, noting the texture, whether sand, silt, or clay, the changes which take place at varying depths, the presence of gravel, the drainage conditions, and the character of the crops or native vegetation. If the borings show a sandy loam to a depth of 6 or 8 inches, and below this a loam grading into a clay at a depth of 24 to 30 inches, the soil would probably be called a sandy loam or a loam, according to the general character of the material as a whole. If these conditions were found to prevail over a considerable area, this sandy loam, or loam, would be recognized as a type and a name given it. Moving forward with their work, if the party found that the material changed, either in the surface soil or in the subsoil, sufficiently to influence plant growth, the character of this change would be noted; and if it were of sufficient importance and covered an appreciable area, a new type would be established. The boundary between the two types would then be traced out, the character of the vegetation or crops, and the physiography of the country frequently being important aids in this work.

Separate samples of the soil and of the subsoil are sent in to the Bureau's laboratories from a number of borings in each of the soils, the number depending upon the extent and importance of the area or the agricultural problems presented therein. These samples are examined in the laboratories, a mechanical analysis is made to show the grade of material composing the soil, and such chemical work is done as experience may indicate will be of probable value in explaining the conditions encountered in the area.

During the months that the parties are in the field they are careful to observe the character and yield of the crops. They are instructed to obtain all possible information from the farmers as to the methods of cultivation, the relation of the soils to drought and to drainage, and in general to acquire the fullest knowledge of the farming conditions in the area. It is clearly recognized that the climate has much to do with the relation of soils to crops, and for this reason a brief statement of the climatic conditions is always given in the reports. It is also recognized that certain economic conditions, frequently local, have a controlling influence upon the relative crop values of soils. The chief among these are the questions of convenience and cost of transportation, the market conditions, and the conditions with respect to labor. These matters are brought out as clearly as possible in the reports of the work.

An idea of the growth of the soil survey work may be gained by comparing the figures for the year 1900 with those for the year 1904. At

the close of the fiscal year ended June 30, 1900, the Bureau had mapped 3,486 square miles, or 2,231,040 acres. Four and a half years later, at the close of the calendar year ended December 31, 1904, it had mapped 88,812 square miles, or 56,867,200 acres. This vast area is distributed among the different States and Territories as follows:

Location and size of areas surveyed and mapped by the Bureau of Soils to December 31, 1904.

State or Territory.	Name of area.	Size of area.	
		Sq. miles.	*Acres.*
Alabama	Blount County	338	216,320
	Fort Payne	509	325,760
	Huntsville	506	323,840
	Lauderdale County	315	201,600
	Macon County	621	397,440
	Mobile	461	295,040
	Montgomery County	338	216,320
	Perry County	762	487,680
	Sumter County	893	571,520
Total for State		4,743	3,035,520
Arizona	Salt River Valley	449	287,360
	Solomonsville	108	69,120
	Yuma	340	216,960
Total for State		897	574,080
Arkansas	Miller County	626	400,640
	Stuttgart	251	160,640
Total for State		877	561,280
California	Bakersfield	195	124,800
	Fresno	628	401,920
	Hanford	216	138,240
	Imperial	1,084	693,760
	Indio	234	149,760
	Los Angeles	570	364,800
	Sacramento	924	591,360
	Salinas Valley	344	220,160
	San Bernardino	755	483,200
	San Gabriel	259	165,760
	San Jose	313	200,320
	Santa Ana	275	176,000
	Stockton	87	55,680
	Ventura	240	153,600
Total for State		6,124	3,919,360
Colorado	Greeley	687	439,680
	Lower Arkansas Valley	945	604,800
	San Luis Valley	628	401,920
Total for State		2,260	1,446,400
Connecticut	Connecticut Valley	505	323,200
Delaware	Dover	314	200,960
Florida	Gadsden County	548	350,720
	Gainesville	485	310,400
Total for State		1,033	661,120

Location and size of areas surveyed and mapped by the Bureau of Soils to December 31, 1904—Continued.

State or Territory.	Name of area.	Size of area.	
		Sq. miles.	*Acres.*
Georgia	Bainbridge	364	232,960
	Cobb County	346	221,440
	Covington	225	144,000
	Dodge County	489	312,960
	Fort Valley	186	119,040
Total for State		1,610	1,030,400
Idaho	Blackfoot	428	273,920
	Boise	399	255,360
	Lewiston	308	197,120
Total for State		1,135	726,400
Illinois	Clay County	460	294,400
	Clinton County	491	314,240
	Johnson County	339	216,960
	Knox County	717	458,880
	McLean County	1,159	741,760
	Sangamon County	866	554,240
	St. Clair County	650	416,000
	Tazewell County	645	412,800
	Winnebago County	526	336,640
Total for State		5,853	3,745,920
Indiana	Boonville	264	168,960
	Madison County	435	278,400
	Marshall County	445	284,800
	Posey County	387	247,680
	Scott County	197	126,080
Total for State		1,728	1,105,920
Iowa	Cerro Gordo County	567	362,880
	Dubuque	440	281,600
	Story County	576	368,640
	Tama County	720	460,800
Total for State		2,303	1,473,920
Kansas	Allen County	504	322,560
	Brown County	378	241,920
	Garden City	335	214,400
	Parsons	398	254,720
	Russell	270	172,800
	Wichita	465	297,600
Total for State		2,350	1,504,000
Kentucky	Mason County	225	144,000
	Scott County	280	179,200
	Union County	361	231,040
	Warren County	533	341,120
Total for State		1,399	895,360
Louisiana	Acadia Parish	636	407,040
	De Soto Parish	825	528,000
	Lake Charles	202	129,280
	New Orleans	410	262,400

Location and size of areas surveyed and mapped by the Bureau of Soils to December 31, 1904—Continued.

State or Territory.	Name of area.	Size of area.	
		Sq. miles.	*Acres.*
Louisiana	Ouachita Parish	605	387,200
	Tangipahoa	228	145,920
Total for State		2,906	1,859,840
Maryland	Calvert County	217	138,880
	Cecil County	376	240,640
	Harford County	418	267,520
	Kent County	293	187,520
	Prince George County	480	307,200
	St. Mary County	363	232,320
	Worcester County	463	296,320
Total for State		2,610	1,670,400
Massachusetts	Connecticut Valley	809	517,760
Michigan	Allegan County	828	529,920
	Alma	282	180,480
	Munising	407	260,480
	Owosso	270	172,800
	Pontiac	307	196,480
	Saginaw	984	630,400
Total for State		3,078	1,969,920
Minnesota	Marshall	233	149,120
Mississippi	Biloxi	615	393,600
	Jackson	737	471,680
	McNeill	198	126,720
	Smedes	463	296,320
	Yazoo	656	419,840
Total for State		2,669	1,708,160
Missouri	Howell County	919	588,160
	O'Fallon	620	396,800
	Saline County	748	465,920
	Shelby County	511	327,040
	Webster County	605	387,200
Total for State		3,403	2,177,920
Montana	Billings	107	68,480
Nebraska	Grand Island	446	285,440
	Kearney	792	506,880
	Stanton	323	206,720
Total for State		1,561	999,040
New Jersey	Salem	493	315,520
	Trenton	810	518,400
Total for State		1,303	833,920
New Mexico	Carlsbad	80	51,200
	Roswell	49	31,360
Total for State		129	82,560
New York	Auburn	461	295,040
	Bigflats	223	142,720
	Dryden	315	201,600

Location and size of areas surveyed and mapped by the Bureau of Soils to December 31, 1904—Continued.

State or Territory.	Name of area.	Size of area.	
		Sq. miles.	*Acres.*
New York	Long Island	845	540,800
	Lyons	515	329,600
	Syracuse	416	266,240
	Westfield	260	166,400
Total for State		3,035	1,942,400
North Carolina	Alamance County	365	233,600
	Asheville	497	318,080
	Cary	63	40,320
	Craven	897	574,080
	Duplin County	340	217,600
	Hickory	988	632,320
	Mount Mitchell	497	318,080
	Parmele	236	151,040
	Pasquotank and Perquimans counties	215	137,600
	Raleigh to Newbern	765	489,600
	Saluda	190	121,600
	Statesville	784	501,760
Total for State		5,837	3,735,680
North Dakota	Cando	283	181,120
	Fargo	406	259,840
	Grand Forks	314	200,960
	Jamestown	496	317,440
Total for State		1,499	959,360
Ohio	Ashtabula	340	217,600
	Columbus	472	302,080
	Coshocton County	551	352,640
	Montgomery County	480	307,200
	Toledo	403	257,920
	Wooster	469	300,160
Total for State		2,715	1,737,600
Oregon	Baker City	158	101,120
	Salem	284	181,760
Total for State		442	282,880
Pennsylvania	Adams County	534	341,760
	Lancaster	269	172,160
	Lebanon	669	428,160
	Lockhaven	278	177,920
Total for State		1,750	1,120,000
Porto Rico	Arecibo to Ponce	330	211,200
Rhode Island	Rhode Island	1,085	694,400
South Carolina	Abbeville	1,006	643,840
	Campobello	515	329,600
	Charleston	352	225,280
	Darlington	599	383,360
	Lancaster County	486	311,040
	Orangeburg	709	453,760
Total for State		3,667	2,346,880
South Dakota	Brookings	484	309,760

Location and size of areas surveyed and mapped by the Bureau of Soils to December 31, 1904—Continued.

State or Territory.	Name of area.	Size of area.	
		Sq. miles.	*Acres.*
Tennessee	Clarksville	547	350,080
	Davidson County	501	320,640
	Greeneville	664	424,960
	Lawrence County	618	395,520
	Pikeville	440	281,600
Total for State		2,770	1,772,800
Texas	Anderson County	1,069	684,160
	Austin	705	451,200
	Brazoria	845	540,800
	Houston County	430	275,200
	Jacksonville	100	64,000
	Lufkin	99	63,360
	Nacogdoches	97	62,080
	Paris	548	350,720
	San Antonio	484	309,760
	Vernon	277	177,280
	Willis	215	137,600
	Woodville	100	64,000
Total for State		4,969	3,180,160
Utah	Bear River Valley	334	213,760
	Provo	373	238,720
	Salt Lake Valley	249	159,360
	Sevier Valley	235	150,400
	Weber County	310	198,400
Total for State		1,501	960,640
Vermont	Champlain Valley	387	247,680
Virginia	Albemarle	1,410	902,400
	Appomattox County	340	202,880
	Bedford	632	404,480
	Gloucester County	250	160,000
	Leesburg	419	268,160
	Norfolk	303	193,920
	Prince Edward	430	275,200
	York Neck	405	259,200
Total for State		4,189	2,680,960
Washington	Walla Walla	201	128,640
	Yakima	309	197,760
Total for State		510	326,400
Wisconsin	Janesville	451	288,640
	Superior	482	308,480
	Viroqua	504	322,560
Total for State		1,437	919,680
Wyoming	Laramie	309	197,760
Grand total		88,855	56,867,200

ADVANTAGES OF THE SOIL SURVEY.

From its surveys the Bureau is steadily accumulating a great mass of information about the various soils found in different parts of the country. This will soon enable it to state accurately what soils are best adapted to the production of different kinds of cotton, tobacco, corn, wheat, and other staple crops. In many localities crops are being grown on soils which are not adapted to them. Thus, in many States attempts are being made to grow wheat on soils so sandy that only a very low yield can be obtained. In other sections of the country attempts are being made to grow early truck on cold, wet clay soils, which are wholly unsuited to such crops. In some of our tobacco-growing States the farmers are growing an inferior leaf, selling for a low price, on lands which are really adapted to special kinds of tobacco, bringing much higher prices. The influence of soil upon the quality of tobacco is so marked that a fine bright tobacco land may be separated by a few feet from one which will produce only a coarse, heavy, inferior leaf. In the mountain fruit districts of our Southern States certain soils are not only adapted to certain fruits, as apples, peaches, grapes, etc., but distinct soils are recognized as best adapted to single varieties of these fruits.

An example is the mountain soil (named by the Bureau Porters black loam) which in Virginia is called "Pippin land," because the celebrated Albemarle Pippin does better on it than on any other soil. With the present system of classification and knowledge of these mountain soils and their adaptation to different varieties of fruits, the Bureau's soil survey parties can enter any of the mountain areas of our Eastern States and quickly and accurately distinguish the good fruit lands from the poor. To one who wishes to engage in the fruit-growing industry in these fertile mountain regions this information is an insurance against loss from purchasing poor fruit soil, and means a great saving of time and money by rendering unnecessary any experiments in planting different varieties on different soils.

The investigation of important agricultural industries which have been developed on soils with certain characteristics enables the Bureau of Soils to recommend safely the introduction of such industries in other localities where similar soils and climatic conditions prevail. An example of this is the mountain peach industry of western Maryland. It was found that peaches of superior quality and flavor could be grown on some of the stony foothill soils of that section which were worthless for general farming purposes. The peaches grown here ripen in season to be placed on the market at a time when the supply from other localities is small and prices correspondingly high. Upon extending the soil survey into other parts of Maryland and into the adjoining State of Virginia the Bureau of Soils was able to recommend the introduction of the mountain peach industry in a number of

places where conditions of soil and climate similar to those of western Maryland were found.

Another example of the value of the Bureau's recommendations is furnished by the soil survey in the Pecos Valley, New Mexico. In the report on this survey a strong recommendation was made to increase the amount of alfalfa grown and to develop the stock-raising industry. During the few years which have elapsed since that recommendation was made attempts at growing fruits and field crops to which the soils and climate were not suited have been largely abandoned, and in their place a profitable stock-raising industry has been developed.

The soil survey is of considerable value also in furnishing instruction as to the cultivation of different kinds of soils in various parts of the country. That sandy soils and heavy clay soils require widely different methods of cultivation has long been known, but the great importance of this has been most clearly brought out by the comparative methods of the soil survey. For example, the proper cultivation of the sandy soils in the cotton-growing districts of the South Atlantic States is well understood, but the productive value of the clay soils is so little appreciated that they have never been given the importance which they deserve. These clay soils would be more productive than the sandy soils if they were properly cultivated. By calling to the attention of the farmers in these districts the profitable yields obtained from similar lands in other parts of the country, and by showing them that the crop yields on those heavy soils would give them a larger net profit, even though the cost of cultivation be greater than on the sandy soils, the Bureau expects to bring about the cultivation of productive soils which have remained practically untouched.

As an illustration of the monetary value of the Bureau's work in establishing the relation between soils and crops, it may be stated that the soils of the Connecticut Valley, which the Bureau declared were adapted to the growing of a superior wrapper tobacco, increased in value more than threefold. The successful termination of the Bureau's experiments in growing Cuban filler tobacco will double or treble the price of certain soil types in our Southern States. Other instances of the increase of land values through the discovery of the adaptation of certain soils to special crops may be cited. The trucking soils of the Atlantic seaboard have increased of late years from a nominal value of $5 an acre to $200 or more an acre. The rice lands of Louisiana have increased in value from $5 to $50 an acre. The Florida soils, adapted to the growing of pineapples, have risen in value from practically nothing to over $500 an acre.

Yet another advantage of the work of the soil survey is the accurate basis which it furnishes for further experimentation. The mapping of the different soils in the several States serves as a true guide for

further experimental work, whether with methods of cultivation, or of crop rotation, or with different manures and fertilizers. So fully is the value of this work realized that some of the State organizations use the soil survey maps as a basis for locating their experimental farms.

In several instances the Bureau of Soils has rendered valuable service to would-be settlers in undeveloped sections of the country. The incorporation of companies to open up and to advertise large tracts of land sometimes leads to the exploitation of regions unsuited to agriculture. The agents of the Bureau have been called on from time to time to investigate these lands, and in some cases have discovered that they were of little or no value to intended settlers, either because of the presence of alkali or because they were not adapted to the only crop suited to the area (as is the case with certain soils in the great wheat belt of the Northwest), and the publication of these facts has saved many home seekers from investing their all in ventures which were bound to prove unprofitable.

In all its work the Bureau of Soils aims at practical results. Its reports deal with everyday problems, and are written with as little use of technical terms as possible. It is not meant by this that the Bureau disregards the scientific side of the many problems with which it has to deal. It has two laboratories—one for chemical and one for physical analyses—in charge of experts of acknowledged ability. The few technical bulletins issued by the Bureau have attracted no little attention from investigators in this line of work. But the technical scientific work has been subordinated to the attainment of practical results.

TOBACCO INVESTIGATIONS.

In connection with the soil survey the Bureau has carried on experiments and demonstration work in growing and handling tobacco. A soil similar to the best tobacco soil of the island of Cuba has been found in several of our Southern States, notably in Texas and Alabama, and experiments in growing the "Cuban filler" tobacco have been carried on for two seasons. While not as fine as the imported Cuban tobacco, the product is believed by experts in the trade to be the finest cigar-filler tobacco ever grown in the United States. It is thought that a profitable filler industry will be established in the South as a result of these experiments.

The discovery of a soil in the Connecticut Valley remarkably similar to the soil in the island of Sumatra, on which the fine Sumatra wrapper leaf is grown, led the Bureau to experiment with the growing of a fine wrapper leaf in several parts of the Connecticut Valley. The tobacco is grown from imported Sumatra seed, under coarse cheesecloth tents, and a very superior wrapper leaf has been produced.

These experiments are still being carried on, in the hope of establishing the industry on a firm commercial basis.

The Bureau has been of considerable assistance to the tobacco industry in Ohio and Pennsylvania through its introduction and practical demonstration of the advantages of the "bulk" method of fermentation. Serious loss from the ravages of a fungus growth, called "black rot," which frequently resulted from the practice of "case" fermenting—that is, packing the tobacco in wooden boxes and storing it in a warehouse for several months—led to a demand for a better method of fermenting tobacco. This was found in the "bulk" method, in which the tobacco is built up on the warehouse floor into large piles, which are torn down and rebuilt whenever the fermentation goes on too rapidly. During the season of 1904 10,208,000 pounds of tobacco was fermented in Ohio under the direction of the Bureau, with no loss from black rot.

Continued demand has been made upon the Bureau to assist the growers of the heavy export types of tobacco used in making plug tobacco and cut tobacco for pipe smoking. A 5-acre experimental farm has been established in Appomattox County, Va., where different fertilizers and methods of culture are being tried to determine which will give the best returns to the growers. It is the intention of the Bureau to extend this work in the future to the other States where these heavy export tobaccos are produced.

RECLAMATION OF ALKALI LAND.

Another special problem is found in the alkali conditions of the arid West. The rise and accumulation of alkali has been one of the most threatening and least understood of the problems confronting the irrigation farmer. There are areas in the West where land has been rendered unfit for crops after having been cultivated for over twenty years. Land which once sold for $300 an acre is now practically worthless. How to prevent the accumulation of alkali in areas not yet damaged, and how to reclaim those that have been injured, is a question the answer to which is eagerly sought.

The presence of alkali is due primarily to the climatic conditions of the West. The soils of the Eastern States have had the salts which they originally contained washed or leached out by the annual rains. The soils of the arid regions of the West, not having undergone this leaching process in the same degree as the eastern soils, contain a large part of the salts which were present in the rocks from which the soils are derived. Usually alkali does not appear in an irrigated district until cultivation has been practiced for a number of years. The substances composing the alkali may be present in the soil before the application of the water, or they may be brought in by the irrigation waters. In hot dry weather, after rains or irrigation, the alkali

frequently appears on the surface of the soil in the form of a white crust.

In most irrigated districts water is used in excessive amounts. Usually the farmer, seeing the benefits derived from irrigation, over-irrigates his land, and as a consequence damage arises from the accumulation of alkali salts and seepage waters. Few irrigated districts are entirely free from alkali after irrigation has been practiced for a few years. Little provision is made for the drainage of lands when irrigation canals are built, the only thought then being to supply the lack of water. Usually the amount of strongly impregnated alkali land is so small that little attention is paid to it, and as the ground water is many feet deep the need of drainage channels is not apparent. After a few years of irrigation with excessive amounts of water the water-table rises, in some cases to within 2 feet or less of the surface.

Then capillary action brings the water to the surface, much as oil rises in a wick, where the water is carried off in the air by evaporation and the alkali salts are left on the surface. Here they accumulate from year to year, until in some instances a crust several inches thick is formed. Soon deep-rooted crops, such as alfalfa, begin to suffer from the rise of ground water, until they are completely drowned out, while the areas of heavily incrusted alkali soils grow appreciably each year. Occasionally a single season suffices to transform a flourishing alfalfa field into a barren alkali flat. This is not the experience of any single irrigated district, but is the common experience of all irrigated countries of little rainfall.

Thus it is seen that one of the drawbacks to irrigation farming is this liability to damage from the rise of alkali and seepage waters unless reasonable precautions are taken. If provision were made for carrying off the surplus water when the supply canals are first built, the trouble from seepage water and alkali would be reduced to a minimum. By using as little water as possible and by frequent shallow cultivation in the case of crops that leave the soil partly exposed, the danger from accumulation of alkali is lessened. Cultivation materially checks surface evaporation, while the restricted use of water reduces the chances of the deep subsoil becoming saturated so soon after irrigation is commenced. Unfortunately, however, few such precautions are taken, and the alkali question becomes more serious from year to year. Even in districts suffering most from this trouble little effort is made to check the spread of alkali. Often from lack of knowledge to fight the evil, or from disinclination to combat it, the farmer abandons land that might be kept in profitable cultivation. In many districts what were formerly the choicest tracts of land are now alkali flats or salt grass pastures. Conservative estimates indicate that on the average from 10 to 15 per cent of the area of every irrigated district

in the United States contains so much alkali as to be unfit for cultivation to any but the most alkali-resistant crops.

Many attempts have been made to free land from alkali by the application of gypsum, stable manure, and other substances, or by washing out the salts by flooding the land and quickly draining the water off the surface. None of these has proved of any permanent benefit to land strongly impregnated with alkali. After careful investigation the Bureau became convinced that the only way permanently to reclaim alkali land where the ground water is near the surface is by underdrainage and flooding. This conviction was strengthened when the Bureau's expert in alkali-land reclamation made a trip to Egypt and Algeria during the summer of 1902 and investigated the work being done there by English and French engineers. In the lower Nile Valley they have reclaimed land so salt that it contained 380 tons of salt per acre to a depth of 3 feet.

The reclamation of alkali land by underdrainage and flooding is purely a mechanical process. The first step is the installation of a complete drainage system. This may consist of deep open ditches, or of box or tile drains. Since hard burnt tile have been found the most economical means of draining wet lands, their use is generally to be recommended. The drain tile should be laid from 4 to 5 feet below the surface, the distance apart of the rows of drains depending upon the character of the soil. In an impervious clay gumbo or adobe soil the tile should be placed at least 100 feet apart, while on coarse, sandy soils they may safely be placed upwards of 300 feet apart. The land is then carefully leveled and "checks" thrown up to keep the water on the land. The land is then flooded to a depth of several inches. The drains carry off the underground or seepage water as fast as it rises to their level, thus breaking the connection between the water table and the soil surface. The flooding dissolves the salt or alkali in the soil above the drains and carries it down and out through the drains, thereby permanently freeing the soil to the depth of the drains from injurious accumulations of alkali, as well as seepage water.

In order to demonstrate the efficiency of this method of reclamation, the Bureau of Soils is underdraining and flooding tracts of land near Salt Lake City, Utah; Fresno, Cal.; North Yakima, Wash.; Tempe, Ariz., and Billings, Mont. At the first two places named, where the reclamation work has been carried on for some time, the lands have been so thoroughly freed from alkali that good crops were grown during the season of 1904, thereby proving that drainage and flooding will reclaim the worst of alkali lands. The results of the work at the other places named have been very satisfactory considering the short length of time the work has been carried on.

Possibilities for improvement in agricultural methods or for the introduction of new crops in an area are constantly presenting themselves to the parties who make the soil surveys. The mere statement in the soil survey reports that certain methods should be adopted or certain crops be grown is not always enough to induce the farmers in the area to make a change in their practices. Practical field demonstration seems to be the best way of impressing these lessons upon the farming class.

A division of soil management has been organized to meet this demand for field demonstration of the practicability of the recommendations contained in the Bureau's reports.

Before carrying on this work in the field preliminary work in the laboratory has been undertaken. A satisfactory method for examining soils in their relation to plant growth has been devised, consisting in growing plants for a period of from three to four weeks in small wire baskets which are completely covered with paraffin on the bottom and sides and sealed on the top, so that the loss of moisture from the soil must take place through the leaves of the plants. The rate at which moisture is given off from the leaf surface is taken as an indication of the rate of growth, although the weight of plants is also ascertained at the close of the experiment and the latter is used in the final results. By this method a large number of soils, or one soil under a variety of conditions, can be examined in a comparatively short period of time. It is proposed to use the results of these preliminary tests as a guide for experimental work in the field. During the season of 1905 it is expected that four or five parties will be sent into the field to test the accuracy of this preliminary method on small tracts of land.

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